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INNOVATIVE ARRANGEMENTS FOR INDUSTRY/DOE LABORATORY COLLABORATION IN HIGH TEMPERATURE SUPERCONDUCTIVITY

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BACKGROUND

The scientific discovery of a new class of materials that are superconducting (able to conduct electricity without energy loss) above the boiling point of nitrogen offers the possibility of revolutionizing many technologies and creating many new applications. These applications could rival, in variety and number, those created by the transistor and the laser.

The race to commercialize this technology is on. The United States must quickly exploit its lead or watch the commercialization of superconductors follow the same path as that of microchips and VCRs. As Frank Press, president of the National Academy of Sciences, recently stated, "superconductivity has become the test case of whether the United States has a technological future." To really excel then, we must explore new partnerships among universities, national laboratories, and industry, making optimum use of the capabilities of all.

President Reagan indicated his support for creative, new collaborative efforts and a fast-paced program at a federal conference on commercial applications of superconductivity, held in Washington, D.C., in July 1987. He clearly expects a strong national laboratory role because he stated earlier that "one focus of the ...quest for excellence... would be to free federal laboratories, including defense labs, to aid in making American products and technology better and more competitive."

Secretary of Energy Herrington has not only strengthened his department's initiatives in basic research in superconductivity, but, on July 30, 1987, asked Los Alamos National Laboratory to "explore private sector interest in the establishment of cooperative research programs to develop enabling technologies for commercial application of superconductivity." He further stated that this "effort could

lead to a pilot program which, if successful, will be expanded to other Department of Energy (DOE) laboratories."

ASSESSMENT OF INDUSTRIAL INTEREST IN HIGH TEMPERATURE SUPERCONDUCTIVITY (HTS)

This report represents an early assessment of industry interest in R & D collaborations with the DOE laboratories in high temperature superconductivity. They are based on a sampling of companies who have expressed interest.

To be successful, collaborative arrangements with the purpose of serving industrial interests, must contain an effective mechanism for assuring the research and development agenda focuses on industry needs. In order to do this, we must first, determine industry needs, then see how DOE laboratories (as a network) can satisfy these needs; second, we must recognize that effective mechanisms to satisfy these needs are not now in place and that DOE and the laboratories must be willing to change how they do business; and third, find an early demonstration that we can work effectively with industry; superconductivity applications is an excellent test. The key conclusions of our assessment are that:

> There is only one reason for industry interest in collaboration with DOE labs: self-interest in attaining their business objectives.
>
> Industry collaboration must be developed. It will take significant time and commitment from industry, labs and DOE to develop this relationship.
>
> If we are to aggressively pursue solutions to industrial competitiveness, innovative new institutional arrangements are needed.

Industry interest in R & D partnerships varies across a spectrum of company purposes and characteristics. Our preliminary findings on how companies would like to work with DOE laboratories are summarized below.

LARGE COMPANIES

Most large companies which have extensive, in-house R & D capability and are not interested in substantive collaboration with government laboratories. They may, when socially or politically motivated, contribute funds to universities or other research institutions, but it is usually viewed as an philanthropic venture. The R & D in federal labs, when focussed on engineering and technology development with commercial potential, is viewed by major companies as a potential threat to their market position. Federally funded R & D helps these companies' smaller competitors and increases the likelihood that their products will be obsoleted before they have exploited them fully. Even if institutional changes could be made to make substantial proprietary R & D possible in the federal laboratories, these companies are very skeptical of the notion that a federal laboratory could effectively partition R & D activities to assure each company's proprietary interests are protected. They are however, interested in maintaining a window on federally funded high temperature superconductor research and development and, in some cases, believe they can leverage their own corporate R & D by working

with the national laboratories.

MID-SIZED COMPANIES

These firms are difficult to characterize other than to say that their common features are: annual revenues of $50 to $500 million dollars, they have limited or no R & D budgets and their future is perceived to depend on innovative new products and capabilities. Mid-sized companies probably benefit most from having free access to the technologies emerging from the federal laboratories and to laboratory experts and facilities. They cannot afford the investment on their own. They would like to have exclusive use of technology developed at public expense. Many of them have developed aggressive strategies for ferreting out good ideas and exploiting them without further involvement with the laboratories. Probably the biggest limitation on this process as an effective technology transfer mechanism is the lack of resources committed to filling development gaps in this part of the innovation cycle.

SMALL COMPANIES

Small companies and entrepreneurs who are developing new products usually look at the laboratories as a source of funds to do R & D they need. When this is done, it allows them to control the use of the development as long as there are not too many strings attached (patents, licenses, etc.). Federal labs in general are not funded to do this kind of work, but the Small Business Innovative Research (SBIR) program is an effective mechanism for small business to accomplish R & D. Small companies may benefit most from partnerships in vertically integrated consortia.

All industries appear to agree on two key roles of the DOE laboratories. The first is the accomplishment of basic research in HTS. The second is the role of providing well characterized materials to industrial researchers, performing measurements and diagnostics for industry and acting as an impartial technical referee in evaluating technical concepts and results.

INSTITUTIONAL MODELS FOR INDUSTRIAL INVOLVEMENT

A number of institutional models for industrial involvement with federal laboratories exist. The efficacy of these models must be tested against the primary criterion of how successful they have been in or could be in assisting U.S. industrial competitiveness. This value judgement is best made by U.S. industry.

Examples of candidate existing models are: NASA's Technology Development Centers, National Science Foundation Engineering Research Centers, the Solar Energy Research Institute and the Sandia National Laboratory Combustion Center. In general, these models do not appear to meet our primary criteria. Thus, new mechanisms are being explored in our discussions with industry. The approaches to developing new models for industrial partnerships are discussed below. These approaches take two general organizational forms. The first form is privately organized entities whose purpose is to combine industry resources to interact with the DOE laboratories. The second form is publicly organized entities whose purpose is to provide an efficient mechanism for industry access to laboratory generated technology. Either or both may be needed. Some companies feel no formal organizations are needed.

Industry Organized Approaches

Vertically Integrated Consortia: The concept of vertically integrated consortia is to form industry partnerships of companies which are not competitors but have a mutual interest in one another's business success. For example, an electric utility, an architect engineering firm, a large power equipment manufacturer, a wire manufacturer, and a material production company could form an R & D partnership. By pooling their R & D dollars, they could diversify their financial risk in developing technologies which would enable their whole industry to compete. The R & D partnership could use DOE laboratory capabilities to develop the enabling technologies which will emerge from high temperature superconductivity research. By sharing the risk of development in a consortium or partnership, it should be possible to enter into long term R & D collaborations necessary to successful applications of high temperature superconductors.

Horizontally Integrated Consortia: This concept is best described by the MCC model for computer research and development. Such a consortium has as partners companies who are willing to share funding and people to jointly perform R & D of mutual interest to each partner. This type of consortium is made up of companies who are competitors in the market place, but who see a strong common interest in collaborating in research. In the case of MCC, the common interest was to counter the common Japanese threat in the microelectronics business.

Unlike the vertically integrated consortia, the horizontally integrated consortia has the disadvantage that the partners are not likely to collaborate on R & D that is close to the commercial market place. Apparently MCC ran into this problem even on research which was far removed from early application.

Regional Entrepreneurial Partnerships: Entrepreneurial spin-offs from federal laboratories has been one of the most effective mechanisms for creating new businesses and the jobs that go with them. The potential for U.S. small business to prosper by exploiting high technology spin-offs has not been fully exploited by U.S. companies. We are constantly facing competition from foreign entities who are aggressively exploiting these opportunities.

The concept of the Regional Entrepreneurial Partnership is to establish regional networks of entrepreneurs, venture capitalists, business support groups, and universities which could work in partnership with national laboratories in various regions of the country. The primary purpose of such partnerships would be to stimulate entrepreneurial activity, to enhance the conditions under which effective access to federal laboratories could be assured, to support small business start ups and to develop strong, new, high tech based industries. A key element in this approach would be obtaining the mutual commitment of all members of the partnership to assure that entrepreneurs are developed and supported in establishing viable small businesses based on high technology products.

DOE LABORATORY ORGANIZED APPROACHES

Exploratory R & D Centers: The concept of Exploratory R & D Centers at appropriate DOE national laboratories is to set up technology partnerships with industry to identify and exploit the most promising enabling technologies, and potential applications of high-temperature superconductors. Prerequisites for creating such centers would include: (1.) demonstrated expertise in superconductivity research and other relevant technologies and (2.) a proven record of performance in exploratory R & D (including people and facilities, the ability to field R & D teams, and to coordinate R & D goals). Industry would be encouraged to participate at the inception, first by providing program guidance and later through cooperative R & D and as a funding source. The centers would perform R & D in:

> Generic, enabling technologies that are pervasive to many potential applications. These efforts are most appropriately funded by the federal government.
>
> More specific enabling technologies that should be cost shared between government and industry, either through industry consortia or individual companies.
>
> Very specific enabling technologies or help with occasional advanced development with full cost recovery from industry. (Naturally, this would result in exclusive intellectual property rights for industry.)

The Exploratory R & D Centers would offer great opportunities to private industry, especially for small and medium-sized companies. The laboratories would provide staff with deep scientific foundations in the physics of superconductivity and other related technologies They also have many of the facilities required for the synthesis, processing, and characterization of the new superconductors. This would allow industry to collaborate with laboratory researchers or try out some of their own ideas without major capital investments and in an environment that is very knowledgeable of what other scientific research is going on in the world. It would also provide almost immediate response, which is crucial in this fast moving field.

These benefits may also be very attractive to some large companies which have traditionally not been involved in superconductivity research or applications. Large companies such as AT & T and IBM may also benefit from scientific collaboration in basic research. They most certainly could contribute in helping to guide the development of generic, enabling technologies. Regardless of size and specific interest of private industry, this initiative would help U.S industry to capitalize on our scientific lead in superconductivity.

The Adjunct Organization: The concept of an adjunct organization is to establish an effective mechanism for industry to gain access to DOE laboratory science and technology, while not interfering with the primary mission of each laboratory. One of the main features of an adjunct organization is the ownership of intellectual property. The intellectual property developed in the adjunct organization belongs to and can be exploited by the adjunct organization separately from federal government rules, regulations and policies. Such an

arrangement has many advantages for both industry and the laboratories:

Ability to contract with industry outside of government control.

Separation of proprietary technology development from laboratory development.

Alternative technical challenge for Laboratory employees to consult and work part-time on industry problems without conflicting with laboratory responsibilities.

Avoids problems of access to sensitive technologies.

Provides working environment for industry and laboratory engineers and scientists to work together on problems of interest to commercial industry.

Laboratory-Industrial Affiliates/Consortia: This approach is typically organized by a laboratory or university and has the main feature of assisting a large number of industrial affiliates to gain effective access to specific areas of laboratory technology. In one form, there are classes of membership with varying membership costs. For example, if a company wants a window on certain technologies being developed in the laboratory, that company can subscribe to a menu of laboratory provided services such as a news letter, prepublications access to selected technologies, participation in educational seminars, state of the art workshops, and some limited amount of free consulting. If the company wants a more substantial involvement, a second class of membership allows them to participate on a collaborative basis with laboratory researchers and appropriate other industry researchers in a jointly-funded and managed research program. In the most fully developed version of this relationship, the laboratory will work with individual companies or will work to arrange R & D partnerships with a small number of companies interested in diversifying both financial and technical risk in the conduct of product/process development to meet specific industry requirements.

Ad Hoc Arrangements: There is a body of opinion that believes a centrally organized approach to exploiting the DOE laboratories' R & D capability is undesirable compared to the ad hoc arrangements that evolve from normal initiatives that drive normal interactions between individuals and institutions. This approach depends upon the competitive spirit of individual companies and laboratories and their ability to initiate and carry through individually tailored arrangements to transfer technology to the private sector.

Although current mechanisms for technology transfer are improving, they continue to be basically an ad hoc process and variable from one laboratory to another. Also, our track record in terms of significant commercialization payoffs has been quite unwarrantable to date, especially when viewed in the light of the right national need to improve industrial competitiveness.

Finally, our policy for assuring fairness in access to laboratory R & D has been to deal with companies and individual entrepreneurs on a first-come, first-serve basis as long as the effort required does not conflict with our ability to carry out the laboratory's mission. Up until recently, this was accomplished with relatively few problems of fair access. This situation is not likely to persist in view of the strong national desire to assure industry has effective, expeditious access to the technical base in the federal laboratories. This further underlines the need for more formal arrangements such as those suggested in this paper.